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Preoperative Breast MRI and Surgical Outcomes in Elderly Women with Invasive Ductal and Lobular Carcinoma: a Population Based Study

Alice K. Fortune-Greeley, PhD[1,2], **Stephanie B. Wheeler, PhD**[1,3], **Anne-Marie Meyer, PhD**[3,4,5], **Katherine E. Reeder-Hayes, MD, MBA**[3,6], **Andrea K. Biddle, PhD**[1], **Hyman B. Muss, MD**[3,6], and **William R. Carpenter, PhD**[1,3,5]

[1]Department of Health Policy and Management, Gillings School of Global Public Health, University of North Carolina, CB#7411, Chapel Hill, NC, 27599

[2]Department of Veterans Affairs, Center of Excellence in Health Services Research in Primary Care, 508 Fulton Street, Durham, NC, 27705

[3]Lineberger Comprehensive Cancer Center, University of North Carolina, CB#7293, Chapel Hill, NC

[4]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina, CB #7435, Chapel Hill, NC 27599

[5]Cecil G. Sheps Center for Health Services Research, University of North Carolina, CB#7590, Chapel Hill, NC, 27599

[6]Division of Oncology, School of Medicine, University of North Carolina, CB#7305, Chapel Hill, NC, 27599

Abstract

Background—Existing evidence suggests that preoperative breast magnetic resonance imaging (MRI) might not improve surgical outcomes in the general breast cancer population. To determine if patients differentially benefit from breast MRI, we examined surgical outcomes—initial mastectomy, reoperation, and final mastectomy rates—among patients grouped by histologic type.

Methods—We identified women diagnosed with early-stage breast cancer from 2004-2007 in the SEER-Medicare dataset. We classified patients as having invasive ductal carcinoma (IDC), invasive lobular carcinoma (ILC), mixed ductal/lobular carcinoma (IDLC) or other histologic type. Medicare claims were used to identify breast MRI and definitive surgeries during the initial surgical treatment episode. We used propensity score methods to account for the differential likelihood of exposure to MRI.

Results—Of the 20,333 patients who met our inclusion criteria for this study, 12.2% had a preoperative breast MRI. Patients with ILC as compared to other histologic groups were most

Corresponding Author Contact Information: Alice K. Fortune-Greeley, PhD Address: Health Services Research and Development (HSR&D) (152) Durham Veterans Affairs (VA) Medical Center 508 Fulton Street, Durham, NC, 27705 Phone: 919-286-0411, ext. 7484 | Fax: 919-416-5836 | agreeley@unc.edu.

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likely to receive MRI (OR: 2.32; 95% CI: [2.02, 2.67]). In the propensity score adjusted analyses, breast MRI was associated with an increased likelihood of an initial mastectomy for all patients and among all histologic subgroups. Among patients with ILC, having a breast MRI was associated with lower odds of a reoperation (OR: 0.59; 95% CI [0.40, 0.86]), and an equal likelihood of a final mastectomy compared to similar patients without a breast MRI. Overall and among patients with IDC and IDLC, breast MRI was not significantly associated with a likelihood of a reoperation but was associated with greater odds of a final mastectomy.

Conclusion—Our study provides evidence in support of the targeted use of preoperative breast MRI among patients with ILC to improve surgical planning; it does not provide evidence for the routine use of breast MRI among all newly diagnosed breast cancer patients or among patients with IDC.

Keywords

Magnetic resonance imaging; Surgery, Outcomes; Invasive lobular carcinoma; SEER-Medicare; Preoperative care

Introduction

Preoperative breast magnetic resonance imaging (MRI) is increasingly used to assess the extent of breast tumor involvement and to inform surgical decision-making for older patients with early-stage invasive breast cancer [1-4]. Despite its rapid adoption, there is a growing body of evidence—including two randomized controlled trials (RCT) and several population based studies—that suggests routine use of preoperative breast MRI results in more extensive surgeries without clear evidence of clinical benefit such as improved surgical outcomes [4-8]. Due to the lack of evidence demonstrating improved outcomes for patients with preoperative breast MRI in the general breast cancer population, it is important to examine and identify subpopulations of breast cancer patients in which the imaging technique may be the most beneficial.

Because of the diffuse growth pattern of invasive lobular carcinoma (ILC), the second most common histologic type of invasive breast cancer, it has been suggested that patients with ILC may be likely more to benefit from preoperative breast MRI than women with invasive ductal carcinoma (IDC) or other histologic types [9, 10]. As compared to women with IDC, women with ILC are more prone to tumors not detected with mammography and ultrasound examination [11, 12], to multifocal and multicentric breast involvement [13], and to have higher reoperation rates [14-16]. Preoperative breast MRI has been found to be highly sensitive in detecting lesions not seen using mammography or ultrasound among patients with ILC [17]. However, only a few studies have examined the association between breast MRI and surgical outcomes in women with ILC [5, 18-20]. These studies were limited in that they were single institution studies [18-20] and an RCT from the United Kingdom[5] with a small number of ILC patients from settings with distinct surgical treatment patterns, health service resources, and insurance structures that may not be generalizable to the US elderly population. A meta-analysis among ILC patients found that breast MRI was associated with an increased likelihood of mastectomy but found only weak evidence that breast MRI was associated with a lower likelihood of a reoperation [8]. Thus, additional evidence is needed to determine the association between preoperative breast MRI and surgical outcomes among patients with ILC in a sample comparable to the US elderly population.

In this retrospective, population-based study, we used the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked dataset to assess the utilization and potential benefits of preoperative breast MRI among newly diagnosed, elderly breast cancer patients by histologic subgroup—IDC, ILC, and IDLC. To evaluate the benefit of breast MRI among different histologic subgroups, we examined the association between preoperative breast MRI and surgical outcomes—initial mastectomy, reoperation, and final mastectomy—for all patients and within each histologic subgroup using propensity score methods.

Methods

Data

We conducted a retrospective study using the SEER-Medicare linked dataset, which is derived from a consortium of population-based cancer registries across the United States linked to Medicare administrative data and healthcare claims [21]. The SEER dataset comprises 17 registries nationwide covers approximately 25% of the incident US cancer population, and is nearly nationally representative [21]. The SEER data contain demographic and incident cancer characteristics, including histology, grade, and stage. Medicare covers payment for hospital services, physician services, some drug therapy, and other medical services for more than 97% of Americans aged 65 and older [22]. The Medicare claims provide information about the use and cost of health care services and co-morbid health conditions. The National Cancer Institute (NCI) hospital file contains hospital-level information, including staffing, structure, research network affiliation, and information on accreditation [22].

Study Population

This study's cohort was composed of women aged 66 or older diagnosed with their first, unilateral, pathologically confirmed, stage I-IIB breast cancer (American Joint Committee on Cancer [AJCC] sixth edition) between January 1, 2004 and December 31, 2007. To capture each patient's complete claims experience, we excluded women who were not continuously enrolled in Medicare Part A and Part B or who were enrolled in a health maintenance organization during the study period. Since this study focuses on the utilization of preoperative breast MRI for surgical planning, we excluded women who received neoadjuvant chemotherapy prior to surgery because breast MRI also is used to measure tumor response to neoadjuvant chemotherapy [23-27]. In order to limit the cohort to women in whom either breast conserving surgery or a mastectomy was likely to be considered, we excluded patients with tumors larger than 5cm [28]. Women who were diagnosed with a second primary cancer identified in SEER within 12 months of diagnosis were excluded in order to avoid including claims for surgeries for second primaries in the initial surgical treatment episode.

To capture health services received by the patients, we examined all claims in Medicare outpatient, inpatient, and physician claims files to identify breast cancer treatments and surgical procedures during the initial surgical treatment episode. Treatments were identified using the American Medical Association Current Procedural Terminology (CPT) and the Healthcare Common Procedure Classification System (HCPCS) codes (for all codes used see Table S1). We defined the initial surgical treatment episode as the time period beginning with the first claim with a diagnosis code for a suspected breast disorder (e.g., lump or mass in breast, or abnormal mammogram) 12 or fewer months prior to the SEER diagnosis. The initial surgical treatment episode ended with the claim for a definitive surgery before a gap in surgery of more than 90 days [29, 30]. We defined definitive surgery as either a partial mastectomy or mastectomy and did not consider open biopsies or breast excisions to be definitive surgeries [7, 31, 32]. Patients who had conflicting claims for a mastectomy and a partial mastectomy on the same day or who did not have their first definitive surgery within four months of their SEER-diagnosis were excluded.

Each patient's tumor histology was classified using International Classification of Diseases for Oncology (ICD-O-3) histologic codes for IDC (M-8500 or M-8521), ILC (M-8520), mixed ductal/lobular carcinoma (IDLC) (M-8522-4), and other histology. Patients with histologic codes that indicated pre-malignant or non-malignant lesions were excluded. Detailed study population and inclusion/exclusion criteria can be found in Table S2.

Variables and Measures

Preoperative breast MRI receipt (our primary independent variable) and the three surgical outcomes of interest—initial surgery, reoperation after partial mastectomy, and final surgery (our dependent variables)—were identified by examining claims in the initial surgical treatment episode. Patients were classified as having a preoperative breast MRI if they had a claim for a breast MRI (CPT: 76093-94, 77058-59, HCPCS: C8903-C8908) before the date of their initial surgery. The initial surgery was defined as the first claim for partial mastectomy or mastectomy during the initial surgical treatment episode. For women with a partial mastectomy as their initial surgery, a reoperation was defined as a claim for another partial mastectomy or mastectomy after the date of the initial surgery but within the initial surgical treatment episode. A sensitivity analysis defining a reoperation as a claim after the initial surgery for an open breast excision, partial mastectomy, or mastectomy within the initial surgical treatment episode produced equivalent results to our main analysis. The final surgery was defined as the last definitive surgery in the initial surgical treatment episode.

We controlled for several other variables that have been previously shown to affect breast cancer surgical decision-making in our analyses [33, 34]. We obtained tumor characteristics from SEER including grade, tumor size, any node positivity, and hormone receptor status. We used the NCI Comorbidity Index method to account for competing health demands and risks of complications that may affect treatment selection [35]. Demographic characteristics examined included age group at diagnosis, marital status, race, Hispanic ethnicity, and SEER region. We included quartiles of the percentage of high school graduates in a given zip code of residence and included a person-level indicator for Medicare state buy-in coverage, which identified women who had their Medicare premiums and deductibles subsidized by the state during the study period owing to their financial status. We identified the facility where the initial surgery took place and linked it to the NCI Hospital file to identify whether or not the facility was a teaching hospital or a designated NCI Cancer Center, and constructed a variable for whether or not the facility was affiliated with NCI Cooperative Groups having breast cancer research portfolios [36]. We also included a variable measuring breast cancer surgical volume. To construct this variable, we used the number of breast cancer surgeries for each surgical facility from 2004-2009.

Statistical Analysis

We compared unadjusted baseline characteristics between patients grouped by histologic type and breast MRI receipt using Pearson chi-squared tests for categorical variables and Student's t-tests for continuous variables. Because previous studies using the SEER-Medicare dataset have shown that patients who receive a preoperative breast MRI differ from women who do not on observed baseline characteristics such as age, race, and health service area resources [1-4], we used propensity score methods to balance the groups of women with and without breast MRI on measured covariates and to control for potential confounders [37]. To estimate the treatment effect of breast MRI in the treated population (i.e., those patients with breast MRI), we used standardized mortality ratio (SMR) propensity score-based weighting [38]. Propensity scores for all patients and for each histologic group were generated using multivariate logistic regression including the patient and surgical facility characteristics described in the previous section [37]. Using SMR weighting, women with breast MRI received a weight of 1 and women without breast MRI were weighted with their propensity odds [38]. We assessed balance and the performance of the model by examining the distribution of propensity scores and covariates between the two groups (MRI vs. no MRI) and the change in standardized difference for each variable before and after weighting [39, 40], and we determined the covariates were well balanced (Figure S1). No patients from the Hawaii SEER region with ILC (n=14) or IDLC (n=18) had an MRI, thus these patients had a zero propensity for breast MRI and were excluded in those subgroup analyses. To generate our propensity score-weighted estimates, we used logistic regression with robust standard errors. Z-test statistics and 95% confidence intervals were used to examine the difference in the likelihood of our surgical outcomes between those women with and without a breast MRI. Traditional multivariate models are presented in the Supplementary Appendix (Tables S3-6) and were similar to our findings using propensity scores.

Analyses were performed using Stata version 12.0 (Stata Corporation, College Station, Texas). All tests were conducted using a minimum significance level of 0.05.

Results

Characteristics of the study population

Of the 20,333 patients who met inclusion criteria, 14,357 (70.6%) had IDC, 1,928 (9.5%) had ILC, and 2,399 (11.8%) had IDLC (Table 1). Demographic, tumor, and surgical facility characteristics significantly differed by histologic type for all variables. Notably, compared to other histologic types, women with ILC were more likely to have tumors that were larger and hormone receptor positive.

Overall, 2,471 (12.2%) patients received a preoperative breast MRI. Breast MRI receipt differed by histologic type with 10.8% of patients with IDC receiving a breast MRI compared to 20.5% of patients with ILC (p-value: <0.001). The number of patients receiving preoperative breast MRI increased over time for all patients and among all histologic types (Figure 1). The subgroups of women with ILC and IDLC saw the greatest increase in use of preoperative breast MRI. From 2004 to 2007, the proportion of patients with preoperative breast MRI increased from 9.6% to 30.6% of those with ILC, from 8.9% to 27.3% of those with IDLC, and from 4.6% to 18.5% of those with IDC.

In the multivariate logistic regression model predicting MRI receipt among all patients in our sample, women with ILC or IDLC were more likely to have received a breast MRI than women with IDC (Table S3). Women with a preoperative breast MRI were on average younger, diagnosed more recently, and with fewer comorbidities overall and among all histologic type subgroups. Women living in lower education areas had greater odds of having an MRI, but having a state buy-in insurance supplement was associated with lower odds of getting MRI. Women having their surgeries at facilities that were affiliated with cooperative groups and a high surgical volume had significantly greater odds of receiving a breast MRI.

Surgical Outcomes

Initial Mastectomy—Among the patients in our sample, 30.1% of patients (n=6,122) had a mastectomy as their initial surgery (Table 2). Patients with ILC had the highest rate of initial mastectomy (35.0%, n=675), and patients with IDLC had the lowest rate (28.7%, n=688). After propensity score adjustment (Figure 2), having a preoperative breast MRI was significantly associated with greater odds of an initial mastectomy for all patients (odds ratio [OR] 1.33; 95% confidence interval [CI] [1.19, 1.48]) and among all histologic types subgroups (IDC OR:1.21; 95% CI [1.07, 1.38]; ILC OR: 1.48; 95% CI [1.10, 2.00]; IDLC OR: 1.98; 95% CI [1.50, 2.62]).

Reoperations—Overall, 20.6% (n=2,929) of women in our sample had an additional reoperation after having an initial breast conserving surgery. Reoperations were most common in women with ILC, (28.3%, n=355) and least common in women with IDC (19.1%, n=1,920). After propensity score adjustment, having a breast MRI was associated with lower odds of having a reoperation among women with ILC (OR: 0.59; 95% CI [0.40, 0.86]), but was not significantly associated with reoperations among other histologic subgroups.

Final Mastectomy—Of all patients in our sample, 35.5% (n=7,224) had a mastectomy as their only or final surgery. Among histologic type subgroups, patients with ILC had the highest percentage of final mastectomies (43.5%, n=839) and patients with IDC had the lowest (34.7%, n=4,984). After propensity score adjustment, breast MRI receipt was associated with increased odds of a final mastectomy among all patients (OR: 1.20; 95% CI [1.08, 1.33]) and among patients with IDC (OR: 1.21; 95% CI [1.07, 1.37]) and IDLC (1.43;

95% CI [1.10, 1.85]). Having a breast MRI was not significantly associated with a final mastectomy in the subgroup of patients with ILC.

Discussion

In this large, population-based study, we found that the association between breast MRI and surgical outcomes differed by histologic subgroup. In particular, among women with ILC, breast MRI was associated with a reduced likelihood of a reoperation and an equal likelihood of a final mastectomy compared to similar patients without a breast MRI. We did not find breast MRI to be associated with improved surgical outcomes overall and among IDC patients and IDLC patients; In fact, in these groups of patients, preoperative breast MRI was significantly associated with an increased likelihood of more extensive surgeries—including both initial and final mastectomy—but not with reoperations.

This is the largest study of breast MRI among ILC patients (n=1,928) to date. Previous research examining the association between breast MRI and surgical outcomes for ILC patients found conflicting results regarding the benefit of breast MRI [5, 8, 18-20]. Our findings are similar to a meta-analysis among ILC patients which found that breast MRI was significantly associated with an increased likelihood of an initial mastectomy and weakly associated with a lower likelihood of a reoperation [8]. Our results differed from the meta-analysis in that the meta-analysis reported that preoperative breast MRI was associated with an increased likelihood of a final mastectomy whereas we found that ILC patients with breast MRI were no more likely to have a final mastectomy than those ILC women who did not receive a preoperative breast MRI. Our results may differ because the included studies were single institution studies [18-20] and one RCT [5] which included only a small number of patients with ILC. Furthermore, these studies reflect surgical practices from single institutions or in the United Kingdom, where breast cancer treatment patterns, decision-making factors, health service/insurance structures, and fiscal considerations may be different than and not generalizable to the US elderly population.

Breast MRI may be most useful in women with ILC because the biological and clinical features of ILC make it difficult to detect by screening and to determine the extent of disease. Women with ILC are more likely to be inadequately imaged with conventional assessment that includes mammography and sonography [11, 12], which in turn can complicate surgical planning and lead to suboptimal surgical outcomes for patients with ILC. We found that patients with ILC received more intensive surgical treatment than patients with other subtypes and were more likely to have an initial mastectomy (35% vs 30%), a reoperation (28% vs 21%), and a final mastectomy (44% vs 36%) compared to all breast cancer patients. Thus, particularly as the incidence of ILC is increasing in older women [9], it is promising that breast MRI may be beneficial to optimize surgical planning and reduce reoperations in this group of women without compromising the likelihood of breast conservation.

Our results contribute to the growing body of literature documenting that routine breast MRI is associated with an increased likelihood of a mastectomy [4-6, 8, 41, 42] and not associated with a reduction in reoperations [5-8, 41-47] among all breast cancer patients.

The results from our analyses among patients with IDC and IDLC provide novel evidence about the association between breast MRI and surgical outcomes in these histologic type subgroups.

Since preoperative breast MRI was not associated with improved surgical outcomes among older women with IDC and IDLC, it is important to assess the potential consequences of the increasing use of preoperative breast MRI in the general population. Concern exists that breast MRI may overestimate tumor size, resulting in a more extensive surgery than may be required to obtain negative margins. In our study, preoperative breast MRI was associated with an increased likelihood of an initial mastectomy and an increased likelihood of a final mastectomy overall and in patients with IDC or IDLC without a reduction in the likelihood of a reoperation. The association between breast MRI and mastectomies could be concerning if women are electing or surgeons are recommending more extensive surgery based on MRI findings that overestimate the true extent of disease or could be adequately managed by radiation and systemic therapy [48]. Additionally, preoperative breast MRI may contribute to greater use of additional diagnostic procedures which carry their own potential morbidities. Studies have found that breast MRI may be associated with more downstream imaging such as follow-up ultrasounds, more biopsies, and treatment delay [44, 49, 50]. The increased morbidity that may arise from the downstream consequences of breast MRI in absence of clear clinical benefit is troubling as more breast cancer patients are having comparatively favorable prognoses, and many clinicians are focusing on reducing treatment burden and morbidity [51].

This study provides evidence to support the targeted use of preoperative breast MRI among patients with ILC. Given that women with ILC were more likely to have a preoperative breast MRI (OR: 2.32; 95% CI: [2.02, 2.67]) than women with other histologic types, some providers or surgical facilities may already be using ILC as section criteria to optimize the benefit of preoperative breast MRI. We did not find evidence to support routine use of preoperative breast MRI among all patients; however, the rapid increase in use of the imaging technique from 2004 to 2007 and the observed variation in preoperative breast MRI by provider and SEER region suggests that it is unlikely that breast MRI is being utilized solely among select subpopulations, such as women with ILC or women inadequately imaged using conventional assessment.

Our study is limited in several aspects. Like all observational studies, we were unable to control for unmeasured confounding. Using propensity score methods, we successfully balanced women with and without breast MRI on observed clinical, sociodemographic, and surgical facility variables; however, we were unable to balance the women on unobserved characteristics that may be associated with breast MRI and our outcomes, and thus we are concerned that our models are underspecified due to variables not available in our dataset. For example, the clinical rationale for why the MRI was ordered is unknown, and we are unable differentiate women who received an MRI as a part of routine preoperative work-up from those women who received an MRI because their tumors were inadequately imaged using conventional assessment. The specific MRI results for each patient are also unknown, and we are unable to verify the extent to which the MRI results changed surgical decision-making using claims data. These unknown factors may be associated with breast MRI receipt and also may influence surgical outcomes. Also, we were unable to control for women who chose to have an initial mastectomy instead of breast conserving surgery based on their preferences. Other mastectomy and reoperation risk factors not available in the SEER-Medicare data included information about multifocal disease, mammographic density and micro-calcifications and surgeon experience and practice style [7, 34, 52-54]. We were, nevertheless, able to control for tumor size, grade and histology, age, advanced stage, hormone receptor negative status, which have also been reported as mastectomy and or reoperation risk factors [52].

As new and advanced imaging modalities such as breast MRI are introduced into clinical practice, it is important to generate evidence about their appropriate use and to inform their dissemination into practice. Our study provides evidence in support of the targeted use of preoperative breast MRI among patients with ILC to improve surgical planning. Our study also adds to the growing body of literature documenting that routine breast MRI among all breast cancer patients is associated with an increased likelihood of a mastectomy and not associated with a reduction in reoperations among the majority of breast cancer patients in whom it is used. Future research should examine the association between preoperative breast MRI and long-term outcomes such as breast cancer recurrence and survival, particularly among patients with ILC.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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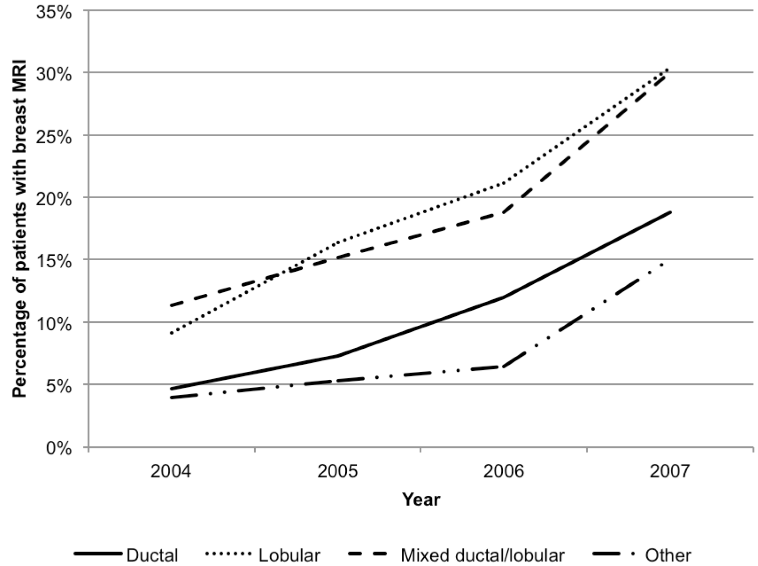

Figure 1.
Percentage of patients with preoperative breast MRI by histologic type

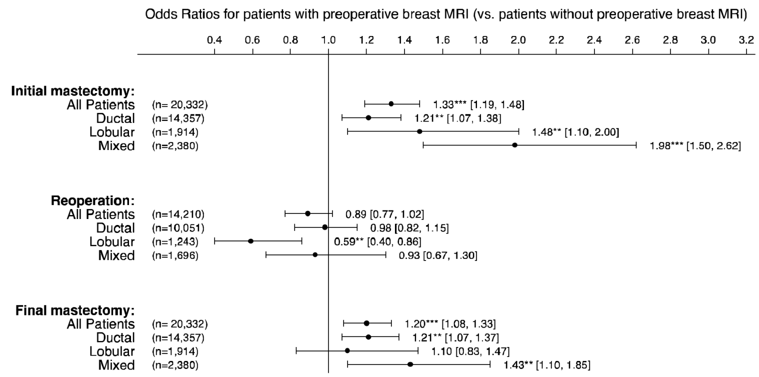

Figure 2. Association between preoperative breast MRI and the odds of surgical outcomes by histologic subgroups adjusted using propensity scores

Estimated propensity score adjusted odds ratio of patients with preoperative breast MRI compared to patients with no MRI is represented by a solid circle (horizontal line represents 95% confidence interval) by surgical outcome and by histologic subgroup. No patients from the Hawaii SEER region with ILC (n=14) or IDLC (n=18) had an MRI, thus these patients had a zero propensity for breast MRI and were excluded in those subgroup analyses.

MRI, Magnetic Resonance Imaging

Table 1

Demographic and cancer characteristics of sample

	All patients	Ductal	Lobular	Mixed ductal/ lobular	p-value
	N= 20,332	N=14,357	N=1,928	N=2,398	
	N (%)	N (%)	N (%)	N (%)	
Preoperative breast MRI	2,471 (12.2%)	1,557 (10.8%)	396 (20.5%)	390 (16.3%)	<0.001
Histology					<0.001
Ductal	14,357 (70.6%)	14,357 (100%)	-	-	
Lobular	1,928 (9.5%)	-	1,928 (100%)	-	
Mixed ductal/lobular	2,398 (11.8%)	-	-	2,398 (100%)	
Other	1,649 (8.1%)	-	-	-	
Tumor Size					<0.001
T < 2cm	14,566 (71.6%)	10,500 (73.1%)	1,192 (61.8%)	1,671 (69.7%)	
T > 2cm, < 5cm	5,766 (28.4%)	3,857 (26.9%)	736 (38.2%)	727 (30.3%)	
Tumor grade					<0.001
Well differentiated	5,221 (25.7%)	3,315 (23.1%)	478 (24.8%)	651 (27.1%)	
Moderately differentiated	8,917 (43.9%)	6,399 (44.6%)	898 (46.6%)	1,177 (49.1%)	
Poorly differentiated	5,140 (25.3%)	4,297 (29.9%)	185 (9.6%)	446 (18.6%)	
Grade unknown	1,054 (5.2%)	346 (2.4%)	367 (19.0%)	124 (5.2%)	
Hormone Receptor Status					<0.001
Positive	15,965 (78.5%)	10,919 (76.1%)	1,697 (88.0%)	2,082 (86.8%)	
Negative	2,705 (13.3%)	2,282 (15.9%)	64 (3.3%)	151 (6.3%)	
Unknown	1,662 (8.2%)	1,156 (8.1%)	167 (8.7%)	165 (6.9%)	
Node positivity	4,360 (21.4%)	3,232 (22.5%)	435 (22.6%)	547 (22.8%)	<0.001
NCI Comorbidity Index					0.001
0	12,996 (63.9%)	9,068 (63.2%)	1,294 (67.1%)	1,597 (66.6%)	
Between 0 and 1	5,648 (27.8%)	4,058 (28.3%)	495 (25.7%)	628 (26.2%)	
Between 1 and 2	1,688 (8.3%)	1,231 (8.6%)	139 (7.2%)	173 (7.2%)	
Age at diagnosis					<0.001
65 to 69	4,215 (20.7%)	3,060 (21.3%)	357 (18.5%)	525 (21.9%)	
70 to 74	4,999 (24.6%)	3,561 (24.8%)	472 (24.5%)	572 (23.9%)	
75 to 79	4,899 (24.1%)	3,424 (23.8%)	463 (24.0%)	594 (24.8%)	
80 to 84	3,791 (18.6%)	2,638 (18.4%)	382 (19.8%)	430 (17.9%)	
85 and older	2,428 (11.9%)	1,674 (11.7%)	254 (13.2%)	277 (11.6%)	
Married	9,312 (45.8%)	6,590 (45.9%)	899 (46.6%)	1,123 (46.8%)	0.05
State buy-in coverage					<0.001
No	18,144 (89.2%)	12,793 (89.1%)	1,761 (91.3%)	2,162 (90.2%)	
Yes	2,188 (10.8%)	1,564 (10.9%)	167 (8.7%)	236 (9.8%)	
Race					<0.001
White	17,652 (86.8%)	12,400 (86.4%)	1,721 (89.3%)	2,134 (89%)	
Non-white	2,680 (13.2%)	1,957 (13.6%)	207 (10.7%)	264 (11%)	

	All patients	Ductal	Lobular	Mixed ductal/ lobular	p-value
	N= 20,332	N=14,357	N=1,928	N=2,398	
	N (%)	N (%)	N (%)	N (%)	
Co-operative group affiliation of surgical facility	10,383 (51.1%)	7,214 (50.2%)	1,023 (53.1%)	1,352 (56.4%)	<0.001
NCI affiliation of surgical facility	1,042 (5.1%)	701 (4.9%)	91 (4.7%)	189 (7.9%)	<0.001
Surgical facility a teaching hospital or affiliated one	10,603 (52.1%)	7,339 (51.1%)	1,041 (54.0%)	1,385 (57.8%)	<0.001
Surgical volume of surgical facility					<0.001
Low volume	9,944 (48.9%)	7,170 (49.9%)	910 (47.2%)	1,010 (42.1%)	
High volume	10,388 (51.1%)	7,187 (50.1%)	1,018 (52.8%)	1,388 (57.9%)	
Zip code proportion with at least high school education (quartiles)					<0.001
Low education	5,055 (24.9%)	3,490 (24.3%)	496 (25.7%)	699 (29.1%)	
Low-medium education	4,890 (24.1%)	3,478 (24.2%)	467 (24.2%)	558 (23.3%)	
Medium-high education	4,793 (23.6%)	3,378 (23.5%)	448 (23.2%)	556 (23.2%)	
High education	4,776 (23.5%)	3,443 (24.0%)	439 (22.8%)	482 (20.1%)	
Unknown education	818 (4.0%)	568 (4%)	78 (4.0%)	103 (4.3%)	
Year of diagnosis					<0.001
2004	5,010 (24.6%)	3,496 (24.4%)	437 (22.7%)	637 (26.6%)	
2005	4,837 (23.8%)	3,381 (23.5%)	461 (23.9%)	572 (23.9%)	
2006	5,194 (25.5%)	3,655 (25.5%)	503 (26.1%)	617 (25.7%)	
2007	5,291 (26.0%)	3,825 (26.6%)	527 (27.3%)	572 (23.9%)	
SEER Region					<0.001
California registries	6,647 (32.7%)	4,725 (32.9%)	595 (30.9%)	810 (33.8%)	
Northeast registries	4,724 (23.2%)	3,187 (22.2%)	490 (25.4%)	704 (29.4%)	
Georgia	680 (3.3%)	499 (3.5%)	63 (3.3%)	73 (3.0%)	
Detroit	1,413 (6.9%)	993 (6.9%)	141 (7.3%)	157 (6.5%)	
Iowa	1,439 (7.1%)	1,059 (7.4%)	145 (7.5%)	117 (4.9%)	
New Mexico	431 (2.1%)	291 (2.0%)	48 (2.5%)	51 (2.1%)	
Seattle	1,207 (5.9%)	866 (6.0%)	131 (6.8%)	129 (5.4%)	
Utah	551 (2.7%)	394 (2.7%)	35 (1.8%)	69 (2.9%)	
Kentucky	1,564 (7.7%)	1,141 (7.9%)	130 (6.7%)	145 (6.0%)	
Louisiana	1,423 (7.0%)	1,005 (7.0%)	136 (7.1%)	125 (5.2%)	
Hawaii	253 (1.2%)	198 (1.4%)	14 (0.7%)	18 (0.8%)	

MRI, Magnetic Resonance Imaging; SEER, Surveillance, Epidemiology and End Results; NCI, National Cancer Institute.

† NCI Cooperative Groups having breast cancer research portfolios

P-values by ANOVA for continuous variables and chi2 test for binary / categorical variables. P-values were based on the differences between the four histologic groups: Ductal, Lobular, Mixed ductal/lobular and other.

Table 2

Surgical outcomes by preoperative breast MRI receipt and histologic subgroups

	Overall		Patients with MRI		Patients without MRI		p-value
	N/ Total subgroup N	%	N/ Total subgroup N	%	N/ Total subgroup N	%	
Initial mastectomy							
All patients	6,122/20,332	30.1%	678/2,471	27.4%	5,444/17,861	30.5%	0.002
IDC	4,306/14,357	30.0%	398/1,557	25.6%	3,908/12,800	30.5%	<0.001
ILC	675/1,928	35.0%	131/396	33.1%	544/1,532	35.5%	0.37
IDLC	688/2,398	28.7%	119/390	30.5%	569/2,008	28.3%	0.38
Reoperation after PM							
All patients	2,929/14,210	20.6%	376/1,793	21.0%	2,553/12,417	20.6%	0.69
IDC	1,920/10,051	19.1%	222/1,159	19.2%	1,698/8,892	19.1%	0.96
ILC	355/1,253	28.3%	67/265	25.3%	288/988	29.1 %	0.21
IDLC	442/1,710	25.8%	69/271	25.5%	373/1,439	25.9%	0.87
Final mastectomy							
All patients	7,224/20,332	35.5%	786/2,471	31.8%	6,438/17,861	36.0%	<0.001
IDC	4,984/14,357	34.7%	468/1,557	30.1%	4,516/12,800	35.3%	<0.001
ILC	839/1,928	43.5%	150/396	37.9%	689/1,532	45.0%	0.01
IDLC	872/2,398	36.4%	132/390	33.8%	740/2,008	36.9%	0.26

P-values by chi2 test between two groups with and without MRI

MRI, Magnetic Resonance Imaging; PM, partial mastectomy.